

XP 000651069



Designation: D 2240 - 95

Standard Test Method for Rubber Property—Durometer Hardness¹

This standard is issued under the fixed designation D 2240; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes seven types of durometers A, B, C, D, DO, O and OO, and the procedure for determining indentation hardness of substances classified as rubber, cellular materials, elastomeric materials, thermoplastic elastomers and some hard plastics.

1.2 This test method is not applicable to the testing of fabrics.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²

D 785 Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials²

D 1349 Practice for Rubber—Standard Temperatures For Testing³

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries³

3. Summary of Test Method

3.1 This test method permits hardness measurements based on either initial indentation or indentation after a specified period of time, or both.

NOTE 1—Durometers with maximum reading pointers used to determine initial hardness values may yield lower hardness when the maximum pointer is used.

4. Significance and Use

4.1 This test method is based on the penetration of a specific type of indenter when forced into the material under specified conditions. The indentation hardness is inversely related to the penetration and is dependent on the elastic modulus and viscoelastic behavior of the material. The shape

of the indenter and the applied force influence the results obtained so there may be no simple relationship between the results obtained with one type of durometer and those obtained with another type of durometer or other instruments for measuring hardness. This test method is an empirical test intended primarily for control purposes. No simple relationship is known to exist between indentation hardness determined by this test method and any fundamental property of the material tested. For specification purposes it is recommended that Test Method D 785 be used for hard material.

NOTE 2—Durometer scale comparison chart only. This is not and cannot be used as a conversion reference.

Type A	10	20	30	40	50	60	70	80	90	100
Type B	10	20	30	40	50	60	70	80	90	100
Type C	10	20	30	40	50	60	70	80	90	100
Type D	10	20	30	40	50	60	70	80	90	100
Type DO	10	20	30	40	50	60	70	80	90	100
Type O	10	20	30	40	50	60	70	80	90	100
Type OO	10	20	30	40	50	60	70	80	90	100

5. Apparatus

5.1 Hardness measuring apparatus or durometer consists of the following components:

5.1.1 *Presser Foot*, with a hole having a diameter as specified in Fig. 1(a), 1(b), or 1(c) with its center at least 6 mm (0.25 in.) from any edge of the foot.

5.1.2 *Indenter*, formed from hardened steel rod and shaped in accordance with Fig. 1(a), 1(b), or 1(c) with full extension adjustable between 2.46 to 2.54 mm (0.97 to 0.100 in.).

5.1.3 *Indenter Extension Indicating Device* (analog or electronic), having a scale reading from 0 to 100 with equal divisions throughout the range. The scale reading is an inverse function of the indenter extension. The device shall have a pointer that moves on the scale at a rate of one hardness point for each 0.025 mm (0.001 in.) of indenter movement.

NOTE 3—Type A Shore Durometers serial numbers 1 through 16 300 and 16 351 through 16 900 and Type A-2 Shore Durometers numbers 1 through 8077 do not meet the requirement of 2.46 to 2.54 mm (0.097 to 0.100 in.) extension of the indenter at zero reading. These durometers will give readings which are low by amounts ranging from 3 units at 30 hardness to 1 unit at 90 hardness.

5.1.4 *Timing Device* (optional), capable of being set to a desired elapsed time, signalling the operator or holding the hardness reading when the desired elapsed time has been reached. The timer should be automatically activated when the presser foot is in firm contact with the specimen being tested.

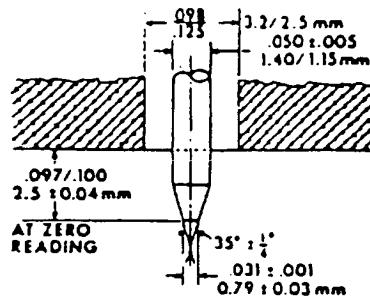
5.1.5 *Calibrated Spring*, for applying force to the indenter in accordance with Fig. 1.

¹ This test method is under the jurisdiction of ASTM Committee D-11 on Rubber and is the direct responsibility of Subcommittee D11.10 on Physical Testing.

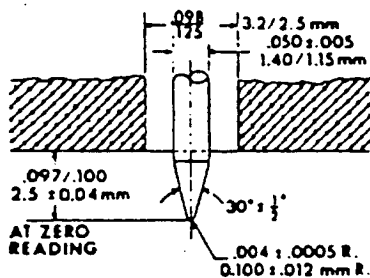
Current edition approved Sept. 10, 1995. Published November 1995. Originally published as D 2240 - 64 T. Last previous edition D 2240 - 91.

² Annual Book of ASTM Standards, Vol 08.01.

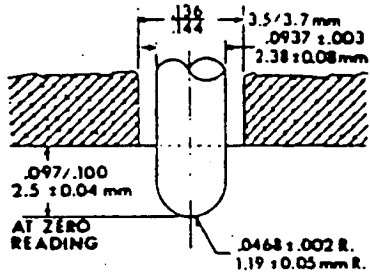
³ Annual Book of ASTM Standards, Vol 09.01.



(a) Indenter for Type A and C Durometers



(b) Indenter for Type B and D Durometers



(c) Indenter for Type DO, O, and OO Durometers

NOTE—Spring Force Combinations:

Force, $N = 0.550 + 0.075 H_s$

where H_s = hardness reading on Type A, B and O durometers.

Force, $N = 0.4445 H_s$

where H_s = hardness reading on Type C, D and DO durometers.

Force, $N = 0.203 + 0.00908 H_{oo}$

where H_{oo} = hardness reading on Type OO durometers.

FIG. 1 Durometer, Indenter and Spring Force Combinations

6. Test Specimen

6.1 The test specimen shall be at least 6 mm (0.25 in.) in thickness unless it is known that results equivalent to the 6 mm values are obtained with a thinner specimen (see Note 4). A specimen may be composed of plied pieces to obtain the necessary thickness, but determinations made on such specimens may not agree with those made on solid specimens because the surface faces between plies may not be in complete contact. The lateral dimensions of the specimen shall be sufficient to permit measurements at least 12 mm (0.5 in.) from any edge unless it is known that identical results are obtained when measurements are made at lesser distance from an edge. The surfaces of the specimen shall be flat and parallel over a sufficient area to permit the presser foot to contact the specimen over an area having a radius of

at least 6 mm (0.25 in.) from the indenter point. A suitable hardness determination cannot be made on a rounded, uneven, or rough surface.

NOTE 4—The minimum requirement for the thickness of the specimen is dependent on the extent of penetration of the indenter into the specimen; that is, thinner specimens may be used for materials having hardness values at the upper end of the scale. The minimum distance from the edge at which measurements may be made likewise decreases as the hardness increases. For materials having hardness values above 50 Type D durometer, the thickness of the specimen should be at least 3 mm (0.12 in.) and measurements should not be made closer than 6 mm (0.25 in.) to any edge.

7. Calibration

7.1 The durometer spring shall be calibrated by supporting the durometer in a vertical position and applying a measurable force to the indenter tip (see Fig. 2). The device used to apply the force may be a dead weight or electronic load cell device capable of measuring applied force at 50 % of the calibration tolerance. Care should be taken to ensure that the force is applied vertically to the indenter tip, as side loads will cause errors in calibration. Spring calibration shall be verified on all durometer at scale readings of 20, 30, 40, 50, 60, 70, 80 and 90. The measured force ($9.8 \times$ mass in kilograms) shall be equivalent to the force calculated by the equation in Fig. 1. The measured force for Type A, B and O durometers shall be within ± 0.08 N. For Type C, D and DO durometers it shall be within ± 0.44 N, and for Type OO durometers it shall be within ± 0.025 N.

NOTE 5—Instruments specifically designed for the calibration of durometers may be used.⁴

7.2 Indenter extension and shape must be in accordance with 5.1.2. With the durometer placed firmly on a flat surface the indicator should read a number equal to the indenter extension measured in inches $\times 1000$, within ± 0.5 durometer points.

NOTE 6—When performing the procedure in 7.2 on Type B and D durometers care should be used not to damage the indenter tip.

7.3 Test blocks (rubber or spring type) provided for checking durometer operation are not to be relied upon as calibration standards. The calibration procedures outlined in 7.1 and 7.2 are the only valid calibration methods.

8. Conditioning

8.1 Tests shall be made at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$). For materials whose hardness depends on relative humidity, the specimen shall be conditioned in accordance with Procedure A of Practice D 618 and tested under the same conditions.

NOTE 7—No conclusive evaluation has been made on durometers at temperatures other than $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$). Conditioning at temperatures other than the above may show changes in calibration. Durometer use at temperatures other than the above should be decided locally (see Practice D 1349).

9. Procedure

9.1 Place the specimen on a hard, horizontal surface.

⁴ Zwick and Co., Control Equipment 7501 with serial numbers higher than WA 20301 or the Shore Durocalibrator, available from Shore Instrument Manufacturing Co., 80 Commercial St., Freeport, NY 11520, have been found satisfactory for this purpose.

Hold the durometer in a vertical position with the point of the indenter at least 12 mm (0.5 in.) from any edge of the specimen, unless it is known that identical results are obtained when measurements are made with the indenter at a lesser distance. Apply the presser foot to the specimen as rapidly as possible, without shock, keeping the foot parallel to the surface of the specimen. Apply just sufficient pressure to obtain firm contact between presser foot and specimen.

NOTE 8—Better repeatability may be obtained by using a mass centered on the axis of the indenter. Recommended masses are 1 kg for Type A, B and O durometers, 5 kg for Type C, D and DO durometers, and 400 g for Type OO durometers. Durometer stands using the masses have as a constant load and a controlled descent speed, without shock, produce maximum repeatability.

9.2 For any material covered in 1.1, after the presser foot is in firm contact with the specimen, the scale reading is to be taken within 1 s or after any period of time agreed upon between supplier and user unless the durometer has a maximum indicator, in which case the maximum reading is taken. The hardness reading may progressively decrease with time delay.

9.3 Make five measurements of hardness at different positions on the specimen at least 6 mm (0.25 in.) apart and determine the arithmetic mean.

NOTE 9—The type of durometer should be selected with the knowledge that readings below 10 or above 90 are not considered reliable by the manufacturer. It is suggested that readings in these ranges not be recorded.

10. Report

10.1 Report the following information:

- 10.1.1 Hardness value obtained.
- 10.1.2 Complete identification of the material tested.
- 10.1.3 Vulcanization date.
- 10.1.4 Description of specimen, including thickness and number of pieces plied, if less than 6 mm (0.25 in.).
- 10.1.5 Temperature of test if other than 23°C.
- 10.1.6 Relative humidity when hardness of material is dependent on humidity.
- 10.1.7 Type and serial number of durometer.
- 10.1.8 Indentation hardness time interval at which reading was taken, and
- 10.1.9 Date of test.

NOTE 10—Readings may be reported in the form: A/45/15 where A is the type of durometer, 45 the reading, and 15 the time in seconds that the pressure foot is in firm contact with the specimen. Similarly, D/60/1 indicates a reading of 60 on the Type D durometer obtained either within 1 s or from a maximum indicator.

11. Precision and Bias⁵

11.1 These precision and bias statements have been prepared in accordance with Practice D 4483. Refer to this Practice for terminology and other testing and statistical concepts.

11.2 The Type 1 precision for both Type A and D methods was determined from an interlaboratory program with three materials of varying hardness, with six participating laboratories. Tests were conducted on two separate

TABLE 1 Type 1 Precision—Type A Durometer Method

Material	Average Level	Within Laboratories			Between Laboratories		
		S_r^A	r^B	(r) ^C	SR^D	R^E	(R) ^F
1	51.4	0.646	1.83	3.56	1.56	4.41	8.59
2	65.3	0.878	2.48	3.81	2.14	6.06	9.27
3	68.0	0.433	1.23	1.80	2.28	6.45	9.49
Pooled	61.6	0.677	1.92	3.11	2.018	5.72	9.28

^A S_r = repeatability standard deviation, measurement units.

^B r = repeatability = $2.83 \times S_r$, measurement units.

^C (r) = repeatability, relative, (that is, in percent).

^D SR = reproducibility standard deviation, measurement units.

^E R = reproducibility = $2.83 \times SR$, measurement units.

^F (R) = reproducibility, relative, (that is, in percent).

TABLE 2 Type 1 Precision—Type D Durometer Method

Material	Average Level	Within Laboratories			Between Laboratories		
		S_r^A	r^B	(r) ^C	SR^D	R^E	(R) ^F
1	42.6	0.316	0.894	2.10	2.82	7.98	18.7
2	54.5	0.791	2.24	4.11	3.54	10.0	18.4
3	82.3	1.01	2.86	3.47	3.54	10.0	12.2
Pooled	59.8	0.762	2.16	3.61	3.32	9.40	15.7

^A S_r = repeatability standard deviation, measurement units.

^B r = repeatability = $2.83 \times S_r$, measurement units.

^C (r) = repeatability, relative, (that is, in percent).

^D SR = reproducibility standard deviation, measurement units.

^E R = reproducibility = $2.83 \times SR$, measurement units.

^F (R) = reproducibility, relative, (that is, in percent).

days in each laboratory for both A and D testing programs. All materials were supplied from a single source.

11.3 A test result for hardness (both A and D) was the median of five individual hardness readings on each day in each laboratory.

11.4 Table 1 shows the precision results for Type A method. Table 2 gives the precision results for Type D method.

11.5 The precision results in this precision and bias section give an estimate of the precision of this test method with the materials (rubbers) used in the particular interlaboratory program as described above. The precision parameters should not be used for acceptance or rejection testing, or both, of any group of materials without documentation that they are applicable to those particular materials and the specific testing protocols that include this test method.

11.6 *Precision*—The precision of this test method may be expressed in the format of the following statements which use as appropriate value r , R , (r) or (R), that is, that value to be used in decisions about test results (obtained with the test method). The appropriate value is that value of r or R associated with a mean level in Tables 1 and 2 closest to the mean level under consideration (at any given time, for any given material) in routine testing operations.

11.6.1 *Repeatability*—The repeatability, r , of this test method has been established as the appropriate value tabulated in Tables 1 and 2. Two single test results, obtained under normal test method procedures, that differ by more than this tabulated r (for any given level) must be considered as derived from different or nonidentical sample populations.

11.6.2 *Reproducibility*—The reproducibility, R , of this test method has been established as the appropriate value tabulated in Tables 1 and 2. Two single test results obtained

⁵ Supporting data are available from ASTM Headquarters. Request RR:D11-029.

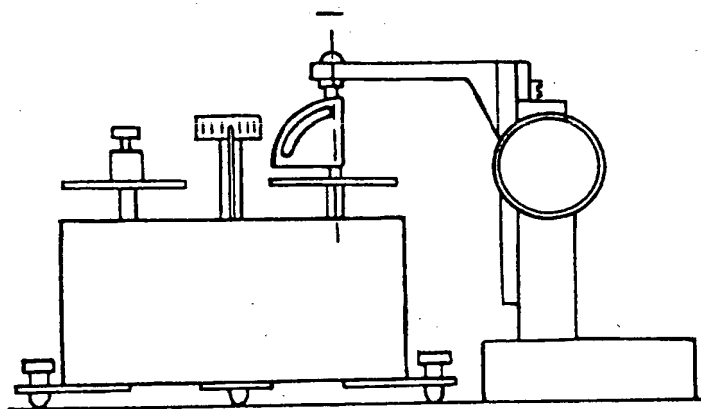


FIG. 2 Apparatus for Calibration of Durometer Spring

in two different laboratories, under normal test method procedures, that differ by more than the tabulated R (for any given level) must be considered to have come from different or nonidentical sample populations.

11.6.3 Repeatability and reproducibility expressed as a percentage of the mean level, (r) and (R) , have equivalent application statements as above for r and R . For the (r) and (R) statements, the difference in the two single test results is expressed as a percentage of the arithmetic mean of the two

test results.

11.7 *Bias*—In test method terminology, bias is the difference between an average test value and the reference (or true) test property value. Reference values do not exist for this test method since the value (of the test property) is exclusively defined by this test method. Bias, therefore, cannot be determined.

12. Keywords

12.1 durometer hardness

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